PHASE 2 PROJECT SUMMARY

Firm: Michigan Aerospace Corporation
Contract Number: NNX09CA24C
Project Title: Advanced Data Mining and Deployment for Integrated Vehicle Health Management and the Space Vehicle Lifecycle

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Identification and Significance of Innovation: *(Limit 200 words or 2,000 characters whichever is less)*

Taiga is a sophisticated tool capable of producing extremely accurate diagnostic and prognostic models on supervised and unsupervised problems for feature-set reduction, classification, regression, clustering, anomaly detection and semi-supervised tasks. Major innovations include: automatic intelligent data imports; highly optimized internal data representations that enable the handling of datasets with more than a billion records and a million features; genetic methods for tree growing in conjunction with Pareto techniques for multi-objective learning; methods for transforming trees into Hilbert Spaces for advanced analysis and redundancy elimination; powerful interactive visualization and drill-down capabilities to provide explanations for observed behavior; and evaluation methods for efficient real-time deployment on platforms such as Field-Programmable Gate Arrays, Digital Signal Processing chips and Graphical Processing Units.

Technical Objectives and Work Plan: *(Limit 200 words or 2,000 characters whichever is less)*
Objective 1: Implement the ***Taiga*** system for state-of-the-art Data Mining with respect to Integrated Vehicle Health Management and the Space Vehicle Lifecycle

A: Optimize the performance of Ensembles of Decision Trees for accuracy, speed and memory footprint

B: Extend the capabilities of Ensembles of Decision Trees to handle pressing requirements for modern pattern recognition

C: Devise practical and valuable visualization techniques for the wealth of information contained in EDTs

D: Seed actual datasets with high-fidelity, realistic anomalies in order to revolutionize the ability to assess and compare Anomaly Detection algorithms

Objective 2: Establish and exploit synergy between existing NASA machine learning approaches and MAC's techniques

Objective 3: With our partner, Optillel, develop a working prototype of an Automatic C++ Parallelizer for the core ***Taiga*** algorithms tailored to NASA hardware platforms, thereby establishing proof of concept for the longer-term objective of a generalized "Write Once, Deploy Anywhere" capability.

Objective 4: Develop and cultivate relationships with partners in industry to secure funds that will qualify MAC for a Phase 2-E Enhancement in order to pursue other fruitful technical avenues with NASA

Technical Accomplishments: *(Limit 200 words or 2,000 characters whichever is less)*
This program resulted in several key technical accomplishments: 1) The Data Handling module of ***Taiga*** can accept any type of data, scale and normalize it, and store it in an efficient format amenable to rapid access for training, 2) the ***Taiga*** System can create ensembles of trees for handling any type of supervised or unsupervised learning problem for classification, regression, clustering and anomaly detection including novel approaches for one-class learning, 3) due to the skilled analysis and coding of Optillel scientists, ***Taiga*** can take advantage of multiple cores at several key levels of granularity to produce results extremely fast even for large data sets, and 4) the ***Taiga*** GUI facilitates training, evaluation and visualization of data and results.

NASA Application(s): *(Limit 100 words or 1,000 characters whichever is less)*
The Intelligent Data Understanding (IDU) Group at NASA-Ames is a prime candidate for collaboration in developing and using ***Taiga***. The most relevant area for ***Taiga*** there is Discovery and Systems Health (DaSH). NASA will benefit from MAC's experience with satellite Threat Assessment with AFRL. ***Taiga*** can be directly applied to problems at DaSH and is highly complementary to software being used and tested within IDU, including Dave Iverson's Inductive Monitoring System (IMS) and Pat Castle's Mariana. With IMS ***Taiga*** complements feature reduction, cluster visualization, explainability, fusion and data synthesis for validation; with Mariana it complements data fusion and parallelization.

Non-NASA Commercial Application(s): *(Limit 200 words or 2,000 characters whichever is less)*
Discovering novel events and anomalies is becoming indispensable for proper operation and maintenance of the complex systems employed by modern industry, medicine, and the military. Factories, health monitors, aircraft and other vehicles regularly produce hundreds or thousands of channels of telemetry in real time, which must be monitored for indications of failure. This presents an extremely diverse market opportunity for ***Taiga***, which will detect events of interest in high-volume data streams of large dimensionality, independent of the raw data source. This diversity is confirmed by the variety of customers who have already expressed interest in MAC's anomaly detection software, including Dow Chemical, Boeing and Space-X. The "Write Once Deploy Anywhere" (WODA) component of ***Taiga*** represents another major commercial opportunity. The emerging trend in hardware from single to multi-core systems is exposing a fast-growing requirement in the software industry for intelligent development tools to aid programmers in converting existing non-parallel algorithms to parallel algorithms. After Phase 2, Optillel will be positioned to license its technology for C++ on any Integrated Development Environment and leverage an enormous pre-existing market. MAC will benefit by being the first partner to use Optillel's WODA technology and reduce development costs for multicore-enabled anomaly detection products.

Name and Address of Principal Investigator: (Name, Organization, Street, City, State, Zip)

John Trenkle
Michigan Aerospace Corporation
1777 Highland Drive, Suite B
Ann Arbor, MI 48108-2285

Name and Address of Offeror: (Firm, Street, City, State, Zip)

Michigan Aerospace Corporation
1777 Highland Drive, Suite B
Ann Arbor, MI 48108-2285